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DARLINGTON NGS UNIT 2 : VIBRATION MONITORING OF LIQUID RELIEF VALVES PV-35 AND PV-36

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ABSTRACT

Vibration monitoring was performed on two liquid relief valves (LRV's), 63310-PV-35 and 63310-PV-36, and their associated piping during Unit 2 commissioning at Darlington NGS. The vibration monitoring was performed to confirm that design modifications to the piping would enable the system to withstand the forces created by LRV operation. No severe vibration was detected under the conditions tested.

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27-032-100	825.5	May 10, 1989	89-101-K

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EXECUTIVE SUMMARY

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Vibration monitoring was performed on two liquid relief valves (LRV's), 63310-PV-35 and 63310-PV-36, and their associated piping during Unit 2 commissioning at Darlington NGS. The vibration monitoring was performed to confirm that design modifications to the piping would enable the system to withstand the forces created by LRV operation.

The valve and piping response were tested under the conditions outlined below.

Test Procedure:

Test 1. Fail open* two LRV's (66310-PV-35 & PV-36) and monitor the response of the instrumented valves and piping;

Test 2. Fail open* all four LRV's and monitor the response of the instrumented valves and piping;

* The valves were failed open by manually pulling fuses on the control panel. Simultaneous opening of the valves cannot be guaranteed by this procedure.

The tests were carried out during commissioning with the PHT system at the following conditions:

1. PHT in normal mode control, temp > 250 C;
2. Bleed condenser in service @ 1.62 MPa, 0.9m;
3. One feed pump in service;
4. PHT pumps P2 and P4 in service.

No severe vibration was detected under the conditions tested.

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To Mr. M.A. Machacek
Manager of Engineering-Darlington
H16G01

DARLINGTON NGS UNIT 2 : VIBRATION MONITORING
OF LIQUID RELIEF VALVES PV-35 AND PV-36

1. INTRODUCTION

In the Primary Heat Transport System (PHTS) of DNGS protection against overpressure is provided by two pneumatic liquid relief valves (LRV's) connected to the west reactor outlet header of each loop of the PHTS (four valves per unit). The valves discharge into the bleed condenser. Vibration monitoring was performed during Unit 2 commissioning at Darlington NGS on two liquid relief valves, 63310-PV35 and -PV36, and their associated piping immediately upstream of the bleed condenser on lines 3310-L26 and -L25 respectively.

The vibration monitoring was performed to confirm that design modifications to the piping enabled the LRV's and associated piping to withstand the forces inherent in LRV operation.

2. TEST PROCEDURE AND INSTRUMENTATION

The instrumentation used for monitoring the valve and piping response are documented below. The piping configuration is shown in Figure 1. The instrumentation locations are marked on the figure.

Instrumentation:

Line 3310-L25:

1. One triaxial accelerometer was mounted at the junction of the body of PV-36 with the downstream piping, location 1, to monitor valve motion in all three directions in acceleration;

2. One proximity probe was mounted on a bracket at PV-36 to record vertical displacement of the valve*;

3. One triaxial accelerometer was rigidly attached to the piping 1.73 m downstream of PV-36, location 2, to monitor piping response in acceleration in three mutually-orthogonal directions.

Line 3310-L26:

1. One triaxial accelerometer was mounted at the junction of the body of PV-35 with the downstream piping, location 3, to record the response in acceleration in three mutually orthogonal directions;

2. One proximity probe was mounted on a bracket at PV-35 to record vertical displacement of the valve*;

3. One uni-axial accelerometer was rigidly attached in the vertical direction to the piping 1 m downstream of PV-35, location 4, to monitor piping response in acceleration in the vertical direction.

* A flat plate had to be attached to the valve body to permit accurate measurement with the proximity probe.

The valve and piping response were tested under the conditions outlined below.

Test Procedure:

Test 1. Fail open* two LRV's (66310-PV-35 &PV-36) and monitor the response of the instrumented valves and piping;

Test 2. Fail open* all four LRV's and monitor the response of the instrumented valves and piping;

* The valves were failed open by manually pulling fuses on the control panel. Simultaneous opening of the valves cannot be guaranteed by this procedure.

The tests were carried out during commissioning with the PHT system at the following conditions:

1. PHT in normal mode control, temp > 250 C;
2. Bleed condenser in service @ 1.62 MPa, 0.9m;
3. One feed pump in service;
4. PHT pumps P2 and P4 in service.

3. RESULTS AND DISCUSSION

The results for Test 1, the two-valve test, are contained in Figures 2 through 14. The real time strip chart records of the valve body displacement and the line response in acceleration for the two-valve test are shown in Figure 2. The spectra of the piping and valve response are contained in Figures 3 through 14.

The vertical displacements of both valves PV-35 and PV-36 in the two-valve test were too low to be accurately measured at the gain levels established. The displacements were significantly less than 1 mm peak-to-peak. The spectrum of PV-36 vertical response in Figure 3 revealed dominant modes at 3.75 Hz and 31.25 Hz. The dominant vertical modes of response for PV-35 were at 16.25 Hz, 31.25 Hz, 135 Hz, and 143.75 Hz as shown in the spectrum in Figure 10. The gains were increased on the proximity probes for the four-valve test following the discovery of the low displacements in the two-valve test.

The piping acceleration levels in the two-valve test ranged from approximately 500 ms^{-2} to 2000 ms^{-2} zero-to-peak. The highest acceleration levels were measured immediately downstream of PV-35, at location 3, in the transverse direction. The spectra of the piping response are contained in Figures 4 through 9 and Figures 11 through 14 for L-25 and L-26 respectively. The spectra revealed that the dominant component of the piping response was from the flow noise which is a broad band excitation at high frequencies in excess of about 5 kHz. The strip chart records demonstrate that the acceleration response increased slightly at the conclusion of the tests as the valves were closed which was expected due to increased pressure drop and cavitation. The acceleration levels measured at the the high frequencies would not contribute significantly to displacement in a forced excitation of the piping.

The results for Test 2, the four-valve test, are contained in Figures 15 through 27. The real time records of the valve displacement and the piping response in acceleration are contained in Figure 15. The spectra of the measured responses are contained in Figures 16 through 27.

The valve displacements during the four-valve test were extremely low. The displacement of PV-36 was too low to be measured accurately. The displacement of PV-35 was less than 0.1 mm peak-to-peak. The dominant modes of response of PV-36, shown in Figure 16, were at 3.75 Hz and 32.5 Hz, similar to the two-valve test. The dominant modes of response of PV-35, shown in Figure 23, were at 15 Hz, 27.5 Hz, 32.5 Hz, 135 Hz, and 143.75 Hz, again, similar to the response with the two-valve test.

The response of L-25 downstream of PV-36 was much lower than that of L26 downstream of PV-35 as shown in Figure 15. The maximum response of L-25 in any direction was less than 1000 ms^{-2} at both locations 1 and 2. The character of the response on L-25 with the four-valve test was different from that with the two-valve test in that the response remained at a constant acceleration level for the duration of the two-valve test whereas in the four-valve test the response of L-25 decreased as soon as the valve opening was complete. The overall vibration levels on L-25 were lower in the four-valve test than in the two-valve test.

The maximum response of L-26 downstream of PV-35 was approximately 2000 ms^{-2}, measured in the transverse direction at location 3, immediately downstream of PV-35. The character and magnitude of the response of L-26 in the four-valve test was similar to that for L-26 in the two-valve test.

The spectra of the piping acceleration response, contained in Figures 17 through 22 for L-25 and Figures 24 through 27 for L-26, revealed that, as in the two-valve test, the acceleration response is dominated by high frequency, broad band components arising from the flow noise. The spectra for the 4-valve tests were taken from the first 7 seconds of the records, which, referring to Figure 15, contains the maximum acceleration levels on L-25.

4. CONCLUSIONS

In the two-valve and four-valve tests of the Unit 2 liquid relief valves at Darlington NGS, no severe vibration was detected under the conditions tested.

Approved:

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HLA:td

Submitted:

H. L. Anderson

H.L. Anderson
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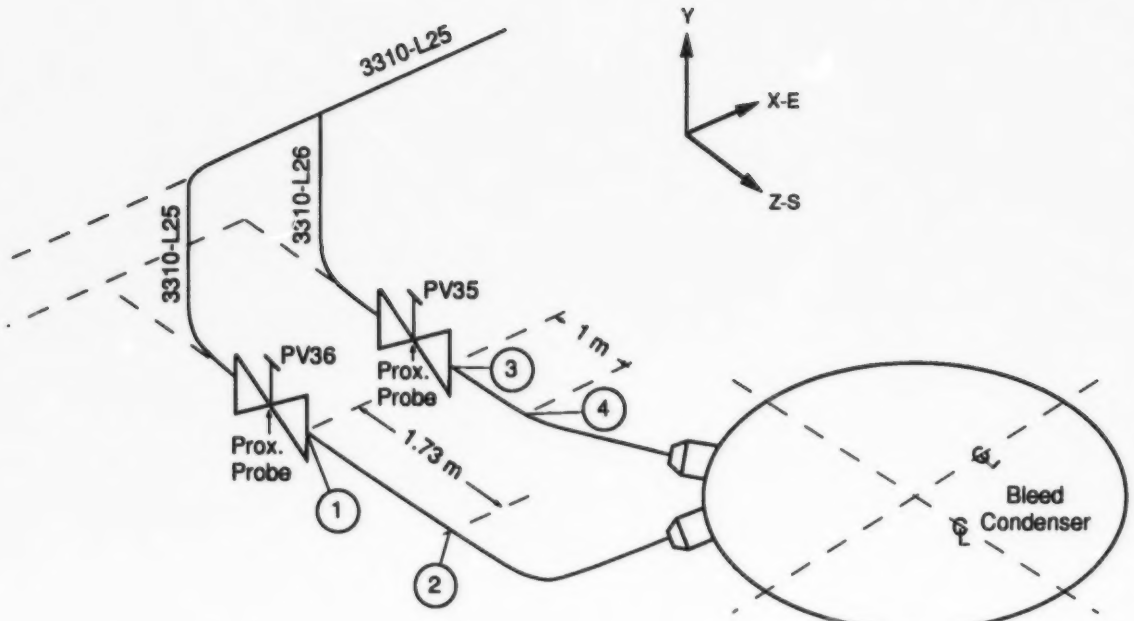

Accelerometer Locations:
(1) Triaxial x, y, z
(2) Triaxial x, y, z
(3) Triaxial x, y, z
(4) Uni-axial y (vertical)

FIGURE 1
INSTRUMENTED PIPING LAYOUT

FIGURE 2
TEST No 1: 2 VALVE LRV TEST

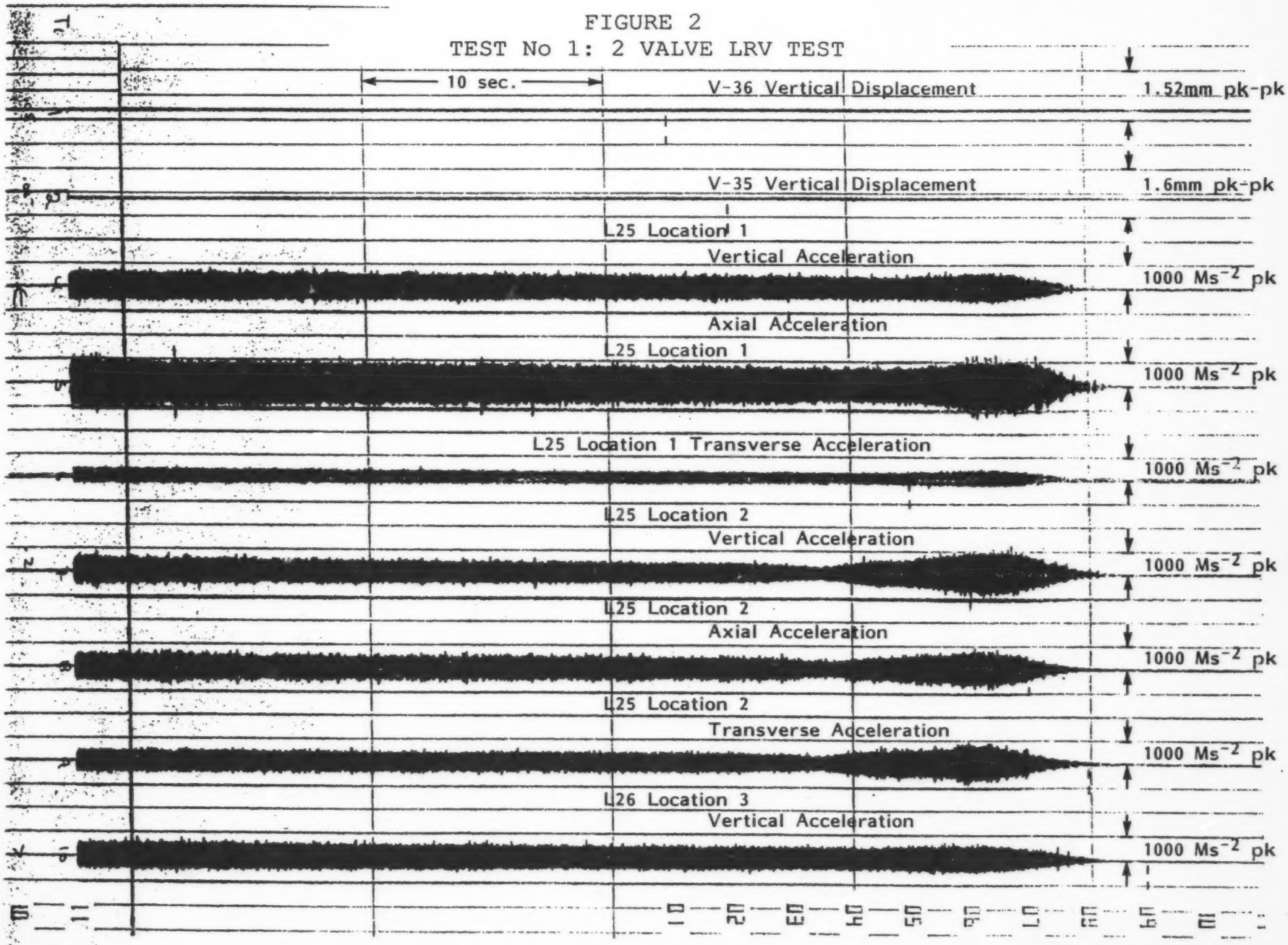

FIGURE 2 (cont'd)
TEST No 1: 2 VALVE LRV TEST

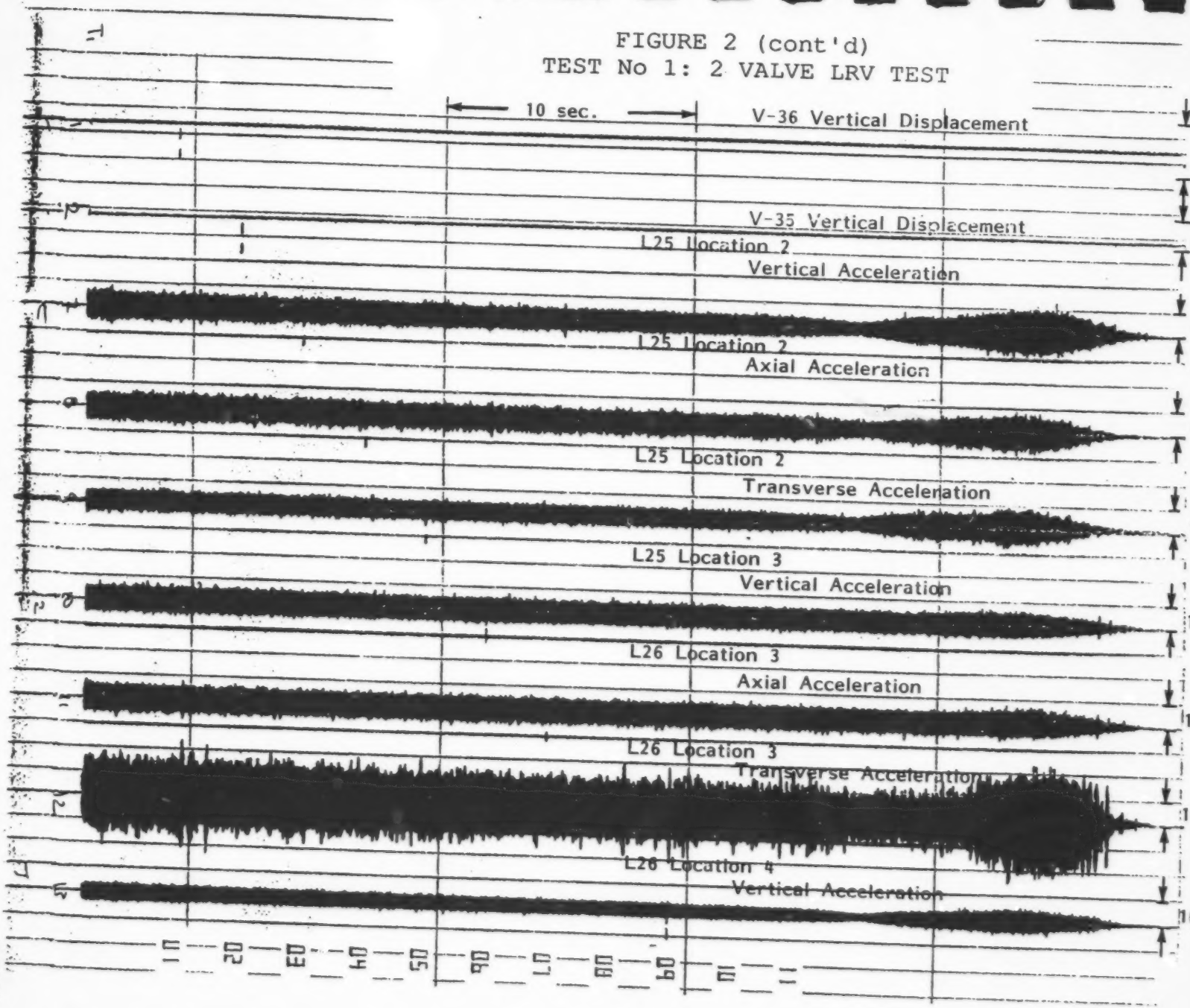

FIGURE 3

DNGS U2 LRV 2 VALVE TEST V-36 VERT DISPL MM 26AUG88

	PEAK SPECTRUM	
1	3.75Hz	.161E-2 mm
2	31.25	.179E-2
3	40.00	.131E-2
4	71.25	.147E-2
5	121.25	.125E-2
6	163.75	.428E-3
7	243.75	.564E-3
8	283.75	.563E-3
9	366.25	.550E-3
10	overall	.639E-2

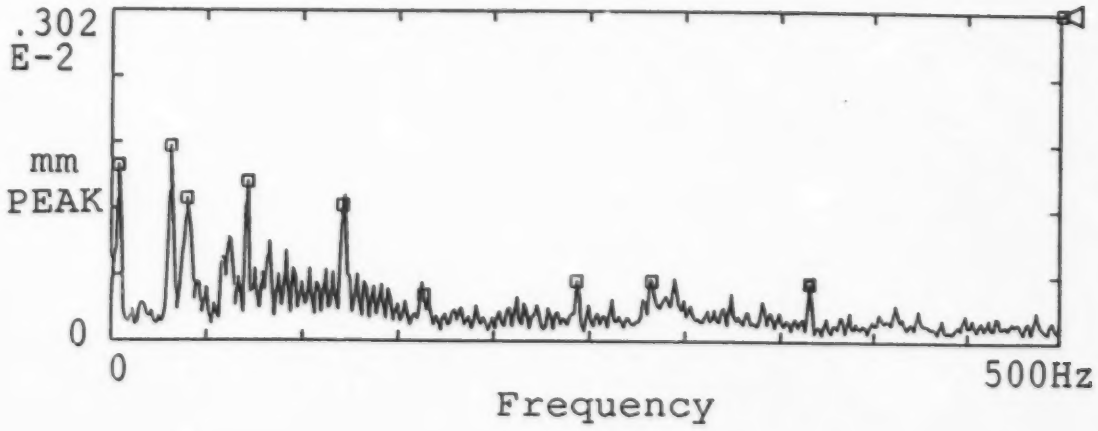

FIGURE 4

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 1 TRANS ACC M/S2 26-AUG-88

	PEAK SPECTRUM	
1	375Hz	.101E+2 m/s^2
2	2475	.883E+1
3	3750	.970E+1
4	4450	.206E+2
5	5325	.178E+2
6	5675	.208E+2
7	5900	.170E+2
8	7475	.656E+1
9	8450	.904E+1
10	10000	.392E+1

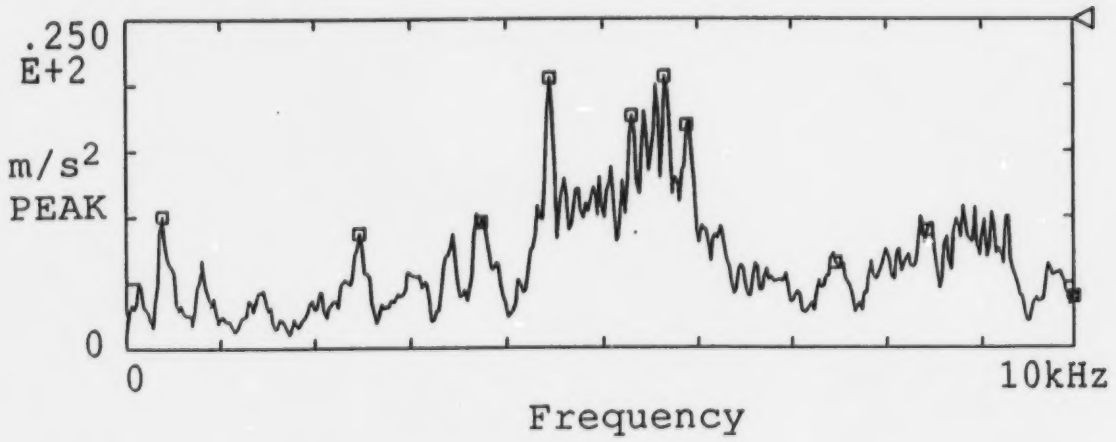

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FIGURE 5

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 1 AXIAL ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	4450Hz	.162E+2	m/s^2
2	4775	.250E+2	
3	5400	.233E+2	
4	5600	.209E+2	
5	5875	.212E+2	
6	6975	.216E+2	
7	7950	.459E+2	
8	9125	.483E+2	
9	9675	.502E+2	
10	overall	.304E+3	

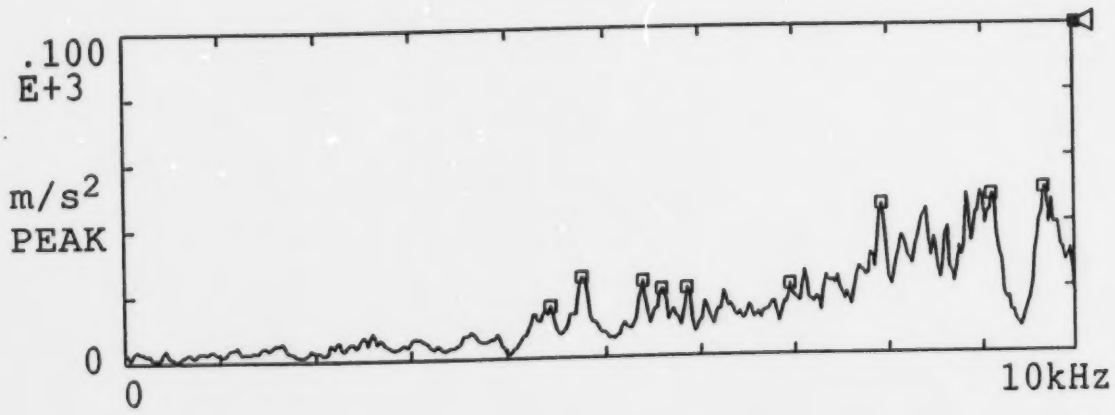

FIGURE 6

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 1 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	2575Hz	.126E+2	m/s^2
2	3400	.127E+2	
3	4400	.397E+2	
4	4850	.353E+2	
5	6450	.143E+2	
6	7125	.181E+2	
7	7550	.243E+2	
8	8475	.183E+2	
9	9175	.491E+2	
10	overall	.228E+3	

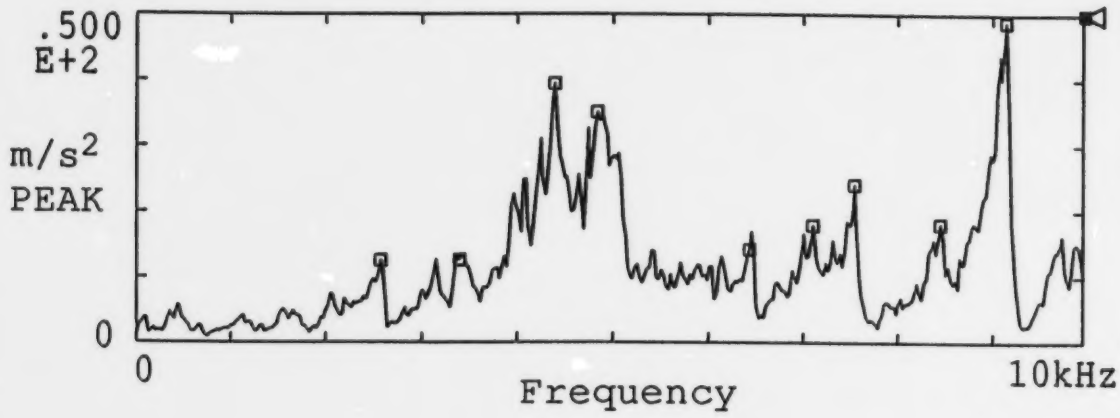

FIGURE 7

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 2 TRANS ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	2275Hz	.122E+2	m/s^2
2	2675	.138E+2	
3	3100	.127E+2	
4	3525	.376E+2	
5	3800	.224E+2	
6	4125	.540E+2	
7	4550	.352E+2	
8	4875	.375E+2	
9	5225	.243E+2	
10	overall	.181E+3	

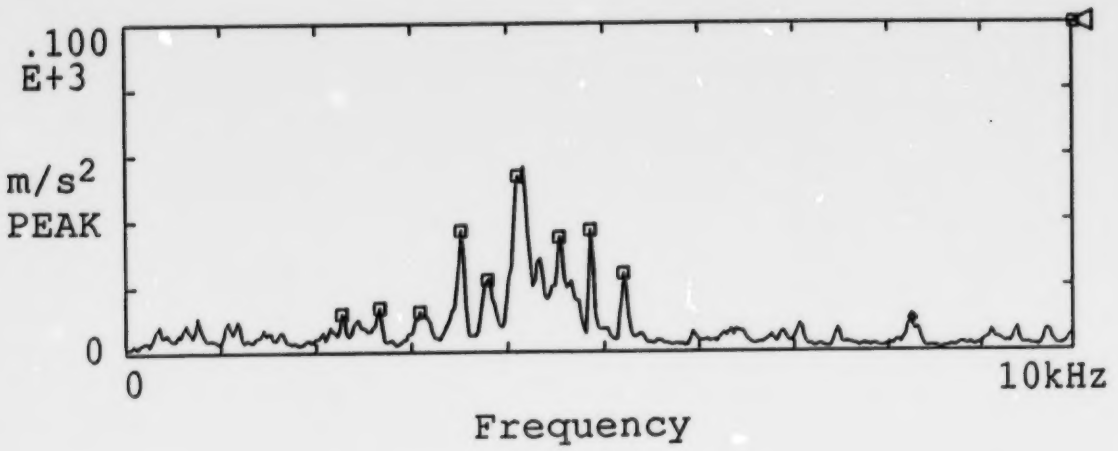

FIGURE 8

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 2 AXIAL ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	3850Hz	.212E+2	m/s^2
2	4175	.336E+2	
3	4400	.843E+2	
4	4575	.415E+2	
5	4725	.420E+2	
6	4950	.622E+2	
7	5025	.571E+2	
8	6325	.914E+1	
9	7025	.954E+1	
10	overall	.237E+3	

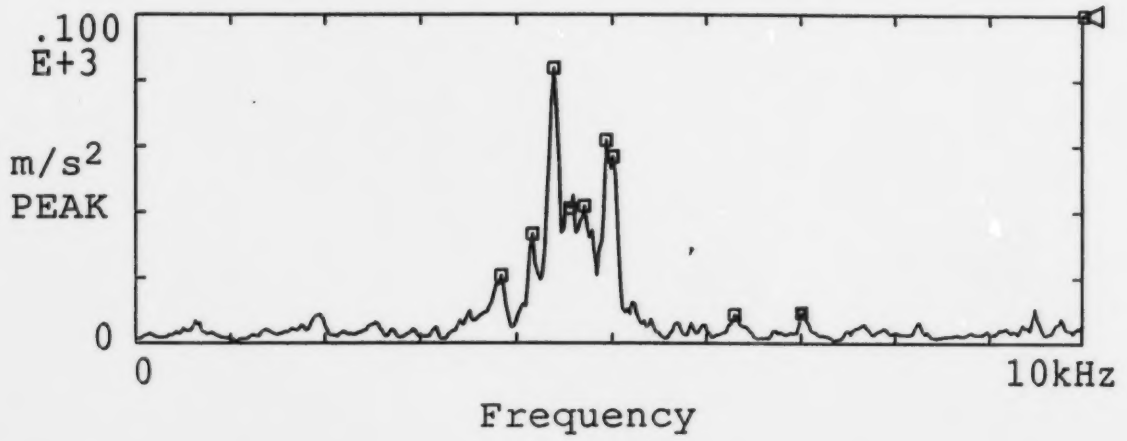

FIGURE 9

DNGS U2 LRV 2 VALVE TEST L-25, LOCATION 2 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	150Hz	.188E+2	m/s^2
2	1350	.134E+2	
3	2600	.213E+2	
4	3550	.287E+2	
5	4150	.281E+2	
6	4400	.285E+2	
7	5000	.502E+2	
8	5425	.162E+2	
9	6300	.158E+2	
10	overall	.184E+3	

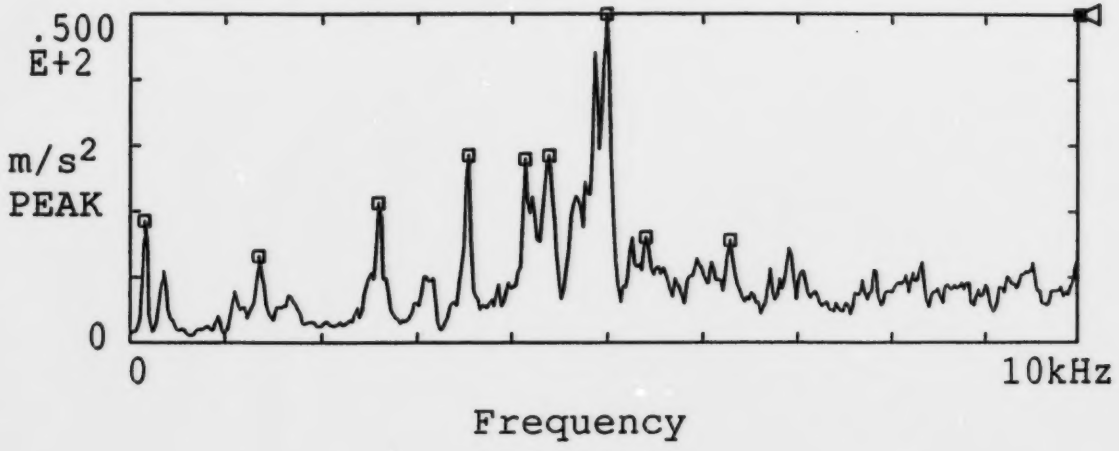

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FIGURE 10

DNGS U2 LRV 2 VALVE TEST V-35 VERT DISPL MM 26AUG88

	PEAK SPECTRUM	
1	16.25Hz	.373E-2 mm
2	31.25	.398E-2
3	51.25	.172E-2
4	61.25	.267E-2
5	122.50	.151E-2
6	135.00	.364E-2
7	143.75	.403E-2
8	233.75	.207E-2
9	290.00	.125E-2
10	overall	.147E-1

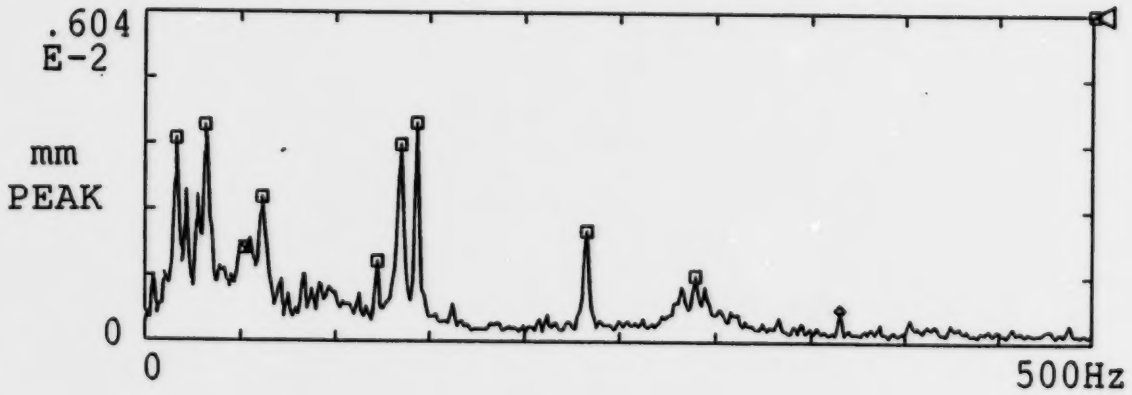

FIGURE 11

DNGS U2 LRV 2 VALVE TEST L-26, LOCATION 3 TRANS ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	2350Hz	.135E+2	m/s^2
2	2650	.112E+2	
3	3350	.174E+2	
4	4800	.317E+2	
5	5500	.255E+2	
6	5850	.316E+2	
7	6225	.340E+2	
8	8825	.462E+2	
9	9250	.553E+2	
10	overall	.405E+3	

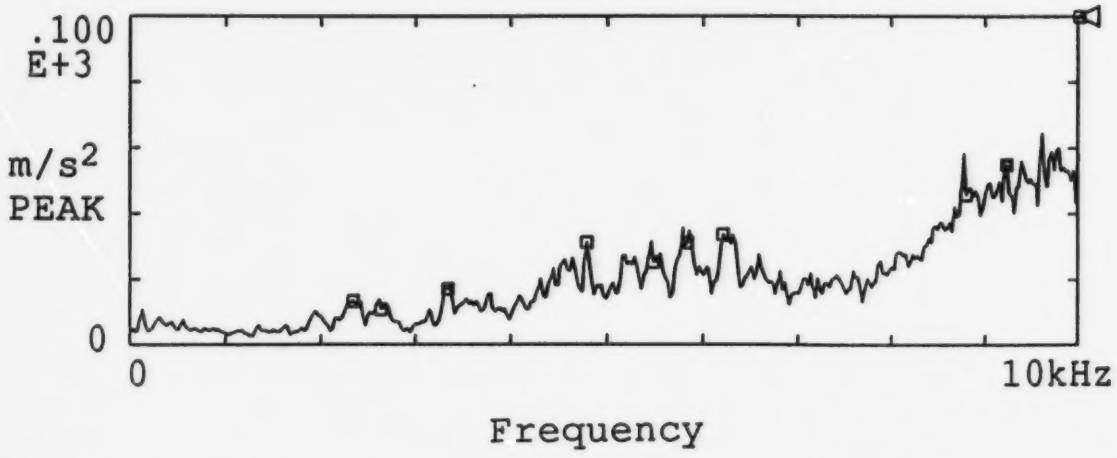

FIGURE 12

DNGS U2 LRV 2 VALVE TEST L-26, LOCATION 3 AXIAL ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	2175Hz	.282E+2	m/s^2
2	2350	.544E+2	
3	2625	.199E+2	
4	3175	.105E+2	
5	4375	.988E+1	
6	4700	.192E+2	
7	5425	.983E+1	
8	6275	.106E+2	
9	7875	.219E+2	
10	overall	.193E+3	

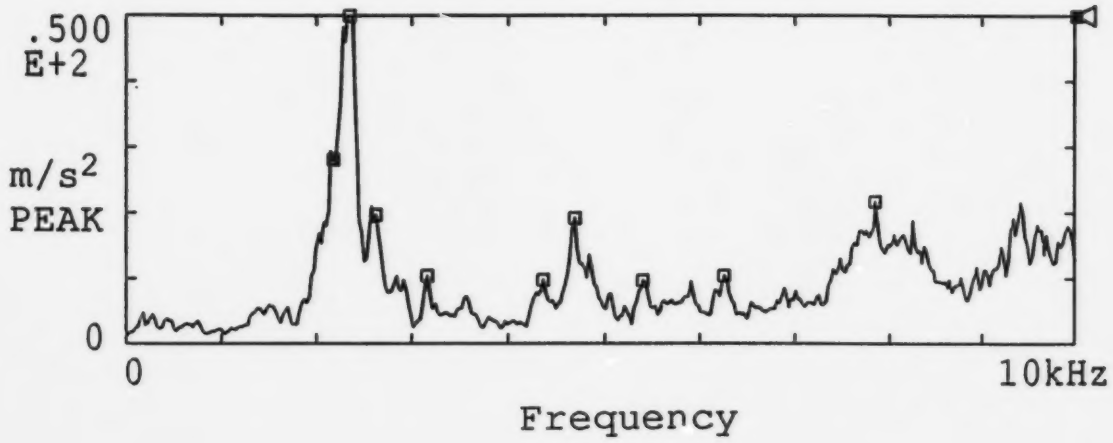

FIGURE 13

DNGS U2 LRV 2 VALVE TEST L-26, LOCATION 3 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM	
1	1925Hz	.179E+2 m/s^2
2	2375	.210E+2
3	2625	.198E+2
4	3175	.522E+2
5	3450	.234E+2
6	4375	.195E+2
7	4850	.225E+2
8	5075	.344E+2
9	5175	.265E+2
10	overall	.175E+3

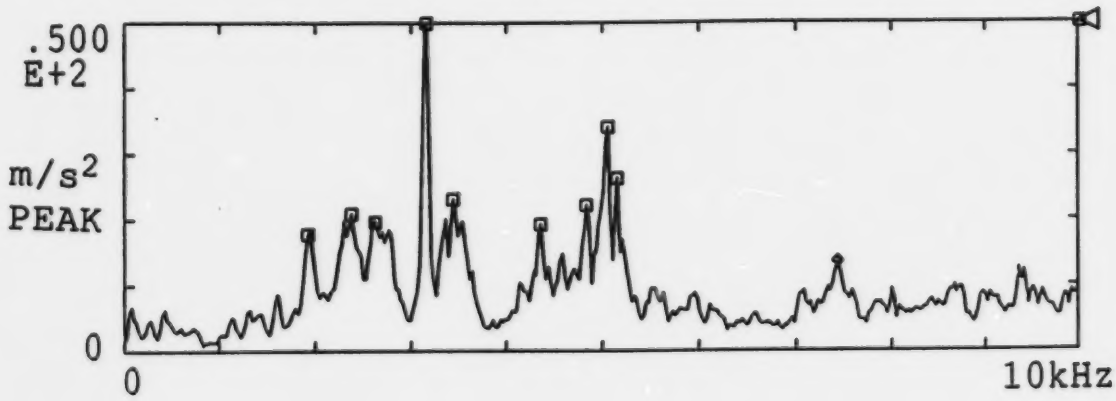

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FIGURE 14

DNGS U2 LRV 2 VALVE TEST L-26, LOCATION 4 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	2625Hz	.128E+2	m/s^2
2	3175	.130E+2	
3	4075	.126E+2	
4	4775	.208E+2	
5	5300	.130E+2	
6	5575	.984E+1	
7	5925	.120E+2	
8	6175	.147E+2	
9	6700	.116E+2	
10	overall	.125E+3	

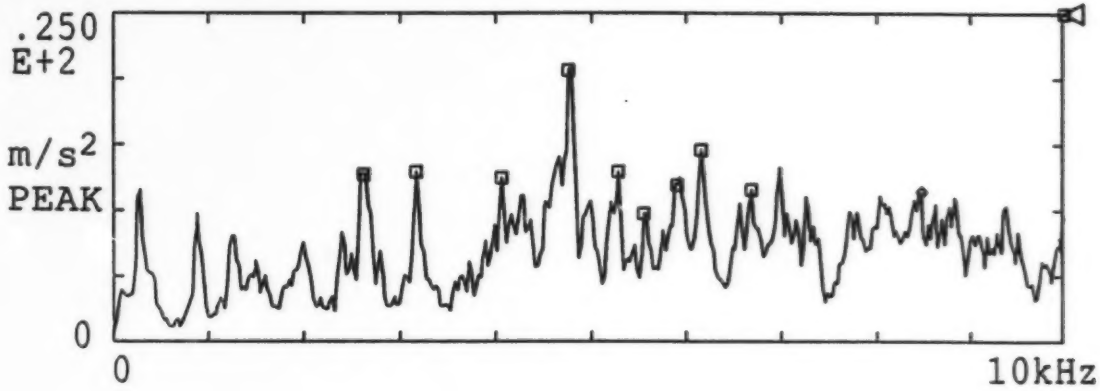

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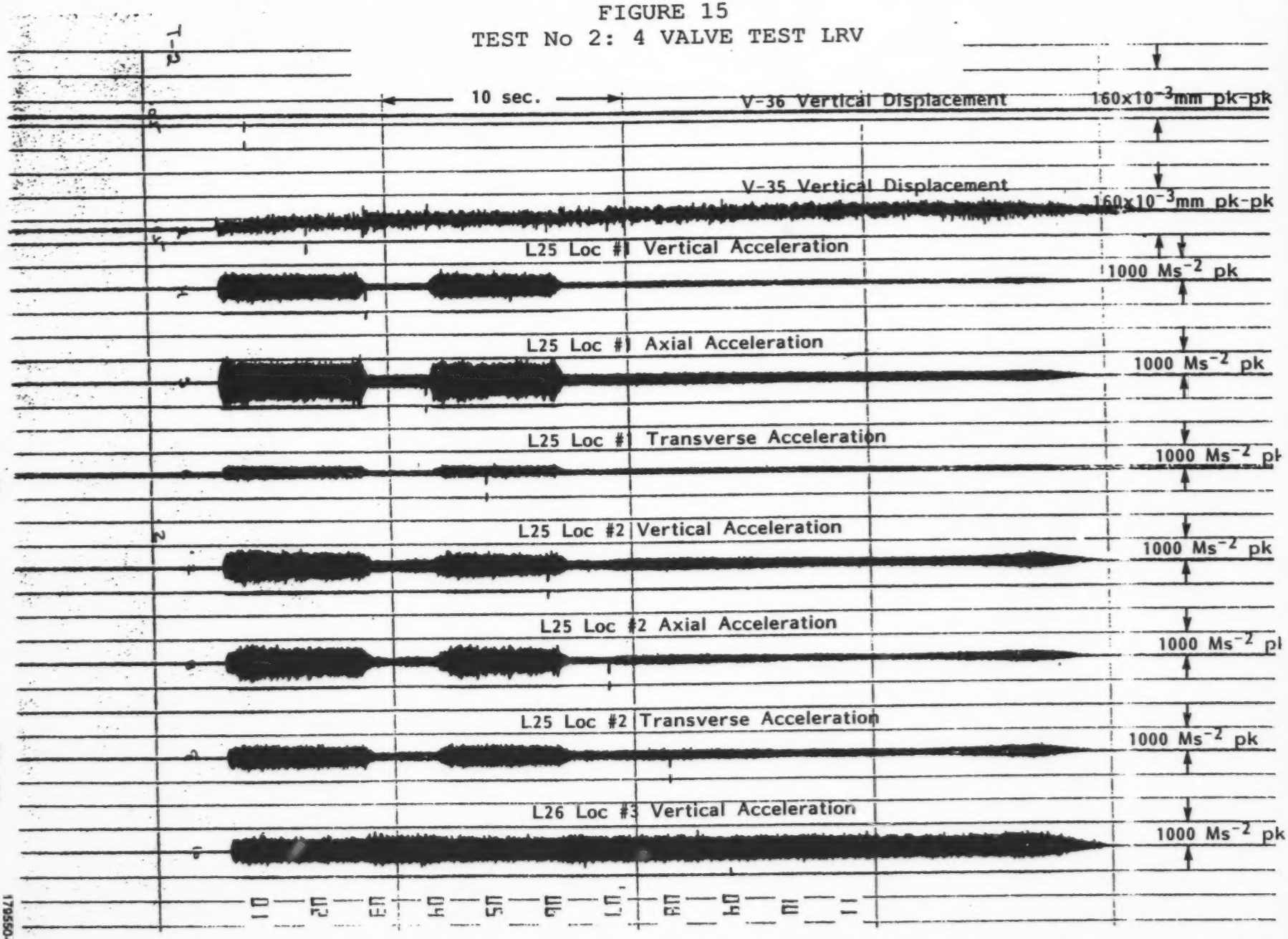
FIGURE 15
TEST No 2: 4 VALVE TEST LRV



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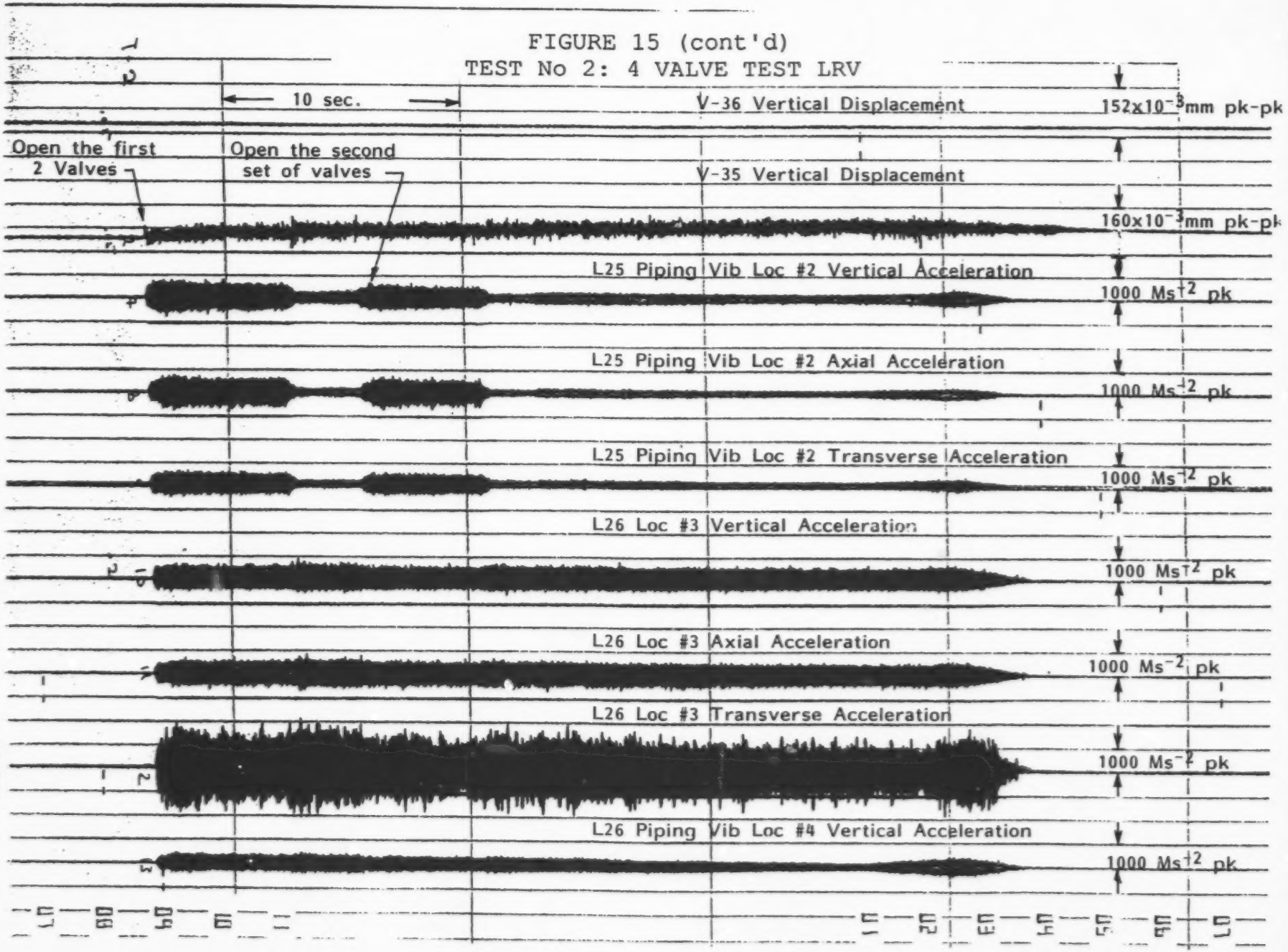

FIGURE 15 (cont'd)
TEST No 2: 4 VALVE TEST LRV

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FIGURE 16

DNGS U2 LRV 4 VALVE TEST V-36 VERT DISPL MM 26AUG88

	PEAK SPECTRUM	
1	3.75Hz	.225E-3 mm
2	32.50	.176E-3
3	61.25	.168E-3
4	72.50	.565E-4
5	122.50	.139E-3
6	180.00	.178E-3
7	243.75	.573E-4
8	283.75	.579E-4
9	300.00	.857E-4
10	overall	.970E-3

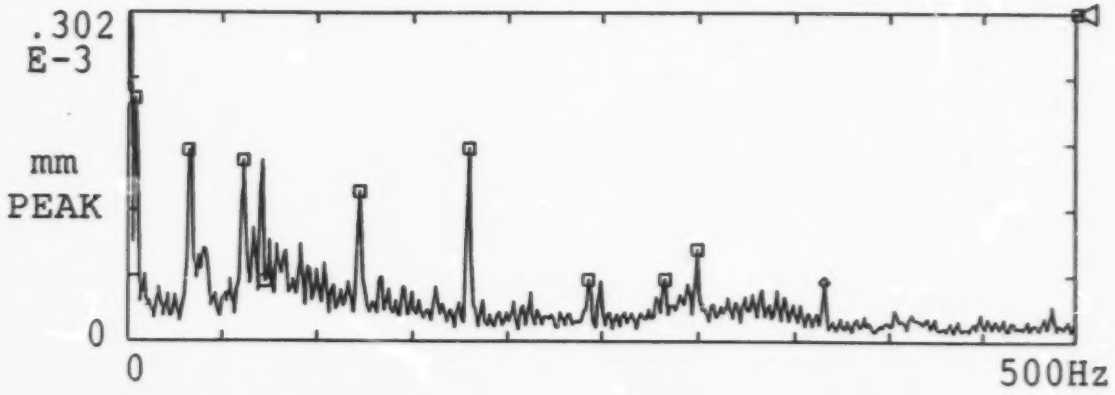
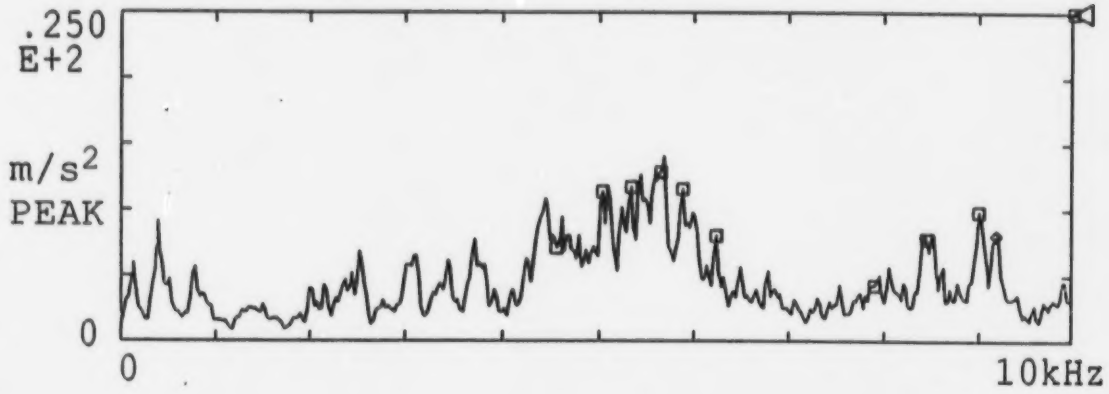


FIGURE 17

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 1 TRANS ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	4575Hz	.711E+1	m/s^2
2	5050	.115E+2	
3	5350	.118E+2	
4	5675	.130E+2	
5	5900	.116E+2	
6	6250	.814E+1	
7	7925	.435E+1	
8	8475	.782E+1	
9	9025	.993E+1	
10	overall	.860E+2	



Frequency

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FIGURE 18

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 1 AXIAL ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	4350Hz	.161E+2	m/s^2
2	4825	.190E+2	
3	5375	.208E+2	
4	7000	.196E+2	
5	7800	.332E+2	
6	8150	.393E+2	
7	8500	.351E+2	
8	8975	.438E+2	
9	9150	.441E+2	
10	overall	.247E+3	

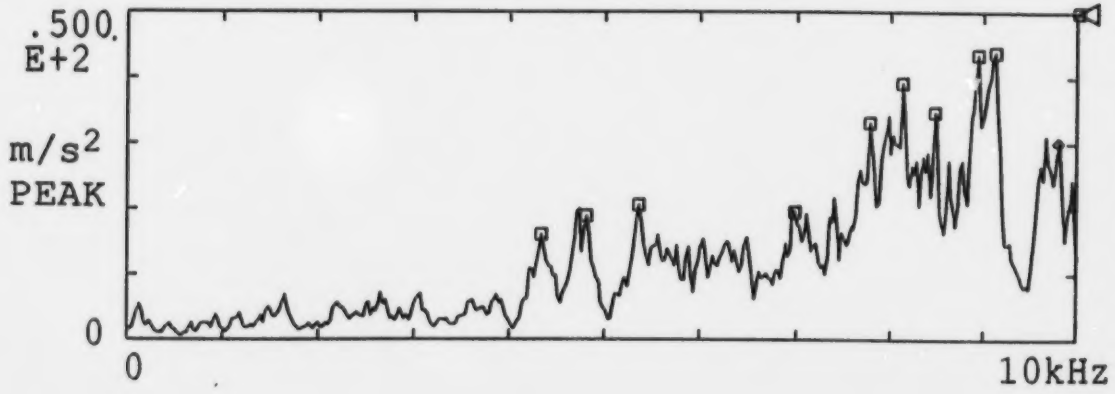

FIGURE 19

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 1 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	3975Hz	.215E+2	m/s^2
2	4375	.339E+2	
3	4425	.338E+2	
4	4875	.293E+2	
5	5075	.195E+2	
6	6475	.121E+2	
7	7050	.172E+2	
8	7525	.128E+2	
9	9125	.277E+2	
10	overall	.172E+3	

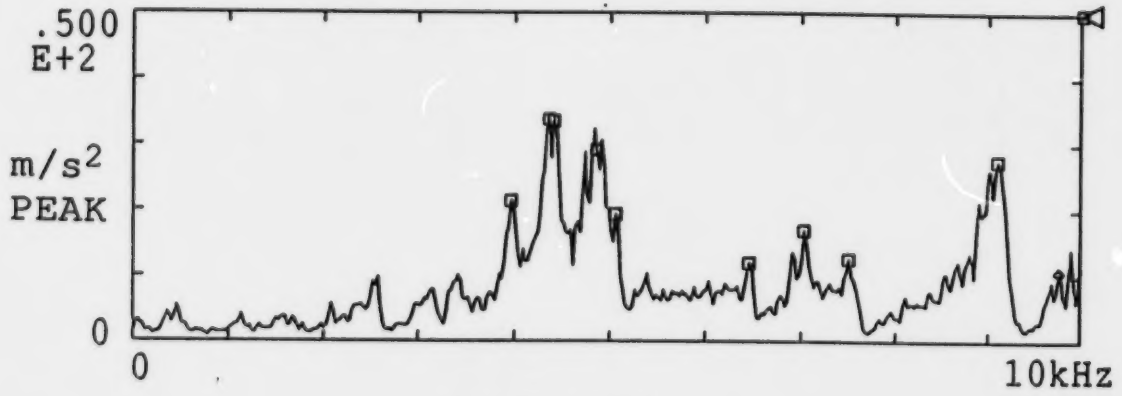

FIGURE 20

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 2 TRANS ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	3075Hz	.134E+2	m/s^2
2	3500	.292E+2	
3	3800	.112E+2	
4	4125	.505E+2	
5	4550	.354E+2	
6	4875	.250E+2	
7	5075	.114E+2	
8	7475	.736E+1	
9	8225	.771E+1	
10	overall	.149E+3	

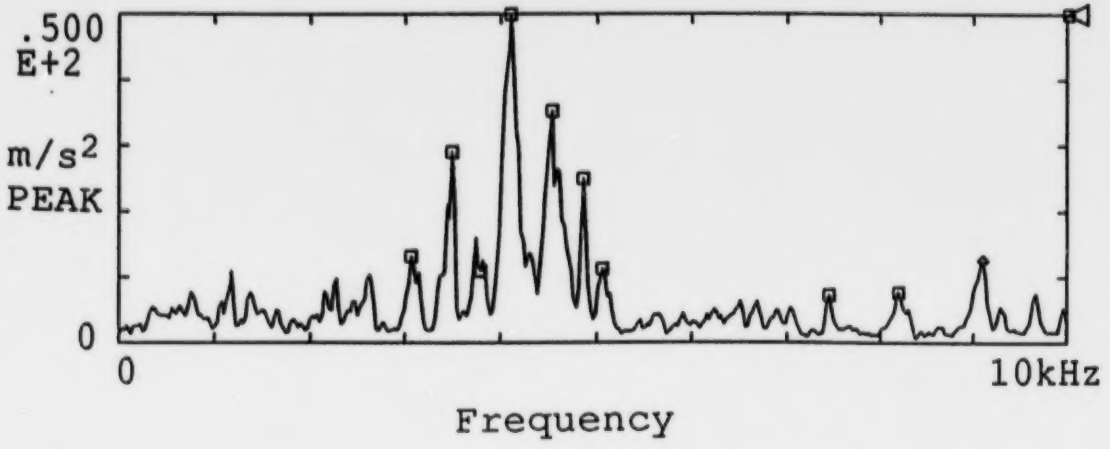

FIGURE 21

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 2 AXIAL ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	4100Hz	.205E+2	m/s^2
2	4400	.662E+2	
3	4575	.590E+2	
4	4800	.581E+2	
5	5050	.556E+2	
6	5925	.975E+1	
7	6975	.800E+1	
8	7475	.989E+1	
9	7675	.878E+1	
10	overall	.216E+3	

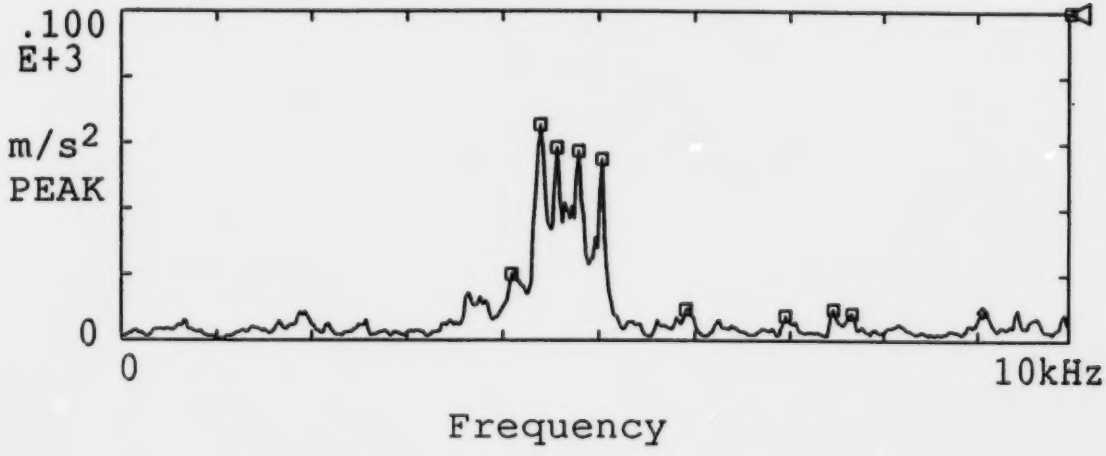

FIGURE 22

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 2 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	1375Hz	.235E+2	m/s^2
2	3475	.169E+2	
3	4100	.224E+2	
4	4800	.461E+2	
5	5450	.124E+2	
6	6900	.162E+2	
7	7050	.180E+2	
8	8125	.146E+2	
9	9575	.148E+2	
10	overall	.171E+3	

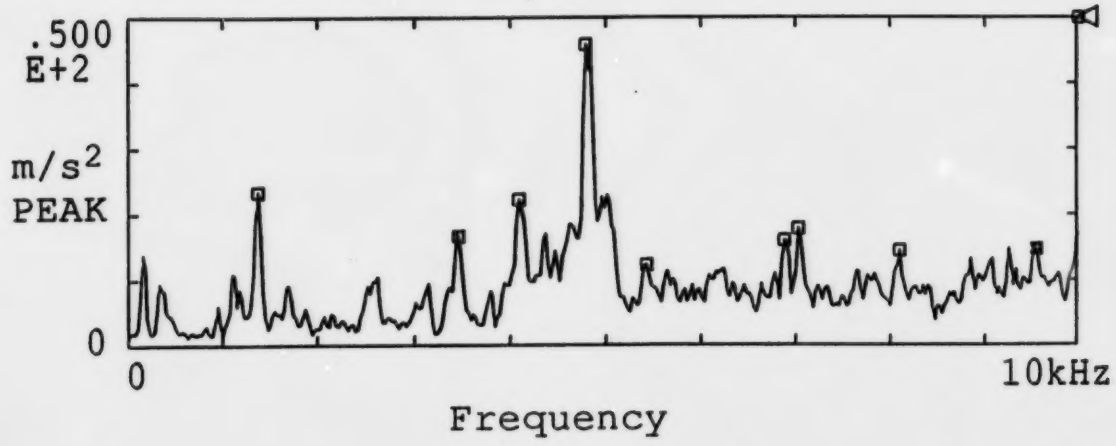

FIGURE 23
DNGS U2 LRV 4 VALVE TEST V-35 VERT DISPL MM 26-AUG-88

	PEAK SPECTRUM		
1	15.00Hz	.455E-2	mm
2	27.50	.289E-2	
3	32.50	.307E-2	
4	50.00	.187E-2	
5	58.75	.246E-2	
6	135.00	.411E-2	
7	143.75	.299E-2	
8	233.75	.142E-2	
9	431.25	.156E-3	
10	overall	.141E-1	

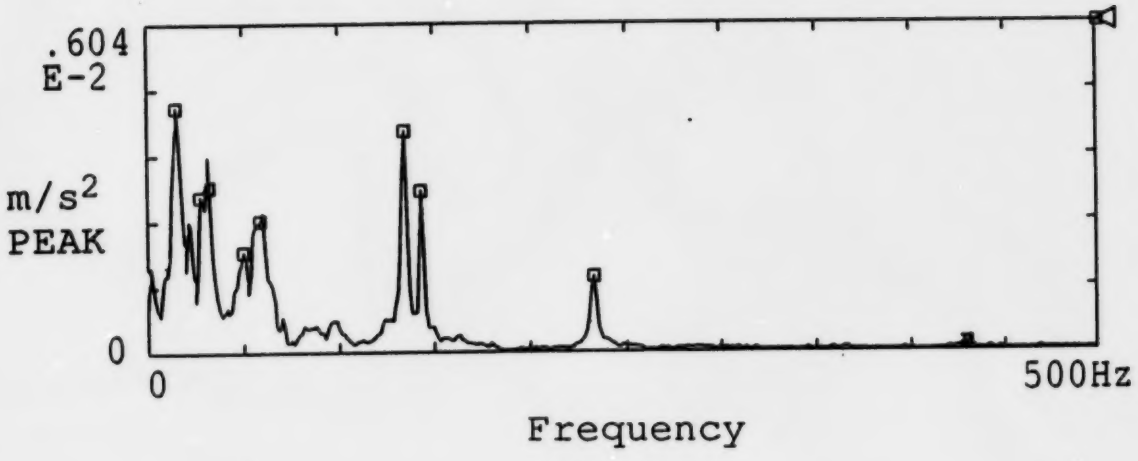

FIGURE 24

DNGS U2 LRV 4 VALVE TEST L-26, LOCATION 3 TRANS ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	3800Hz	.195E+2	m/s^2
2	4775	.279E+2	
3	5525	.322E+2	
4	6175	.311E+2	
5	7100	.213E+2	
6	8475	.457E+2	
7	9125	.581E+2	
8	9450	.656E+2	
9	9700	.573E+2	
10	overall	.368E+3	

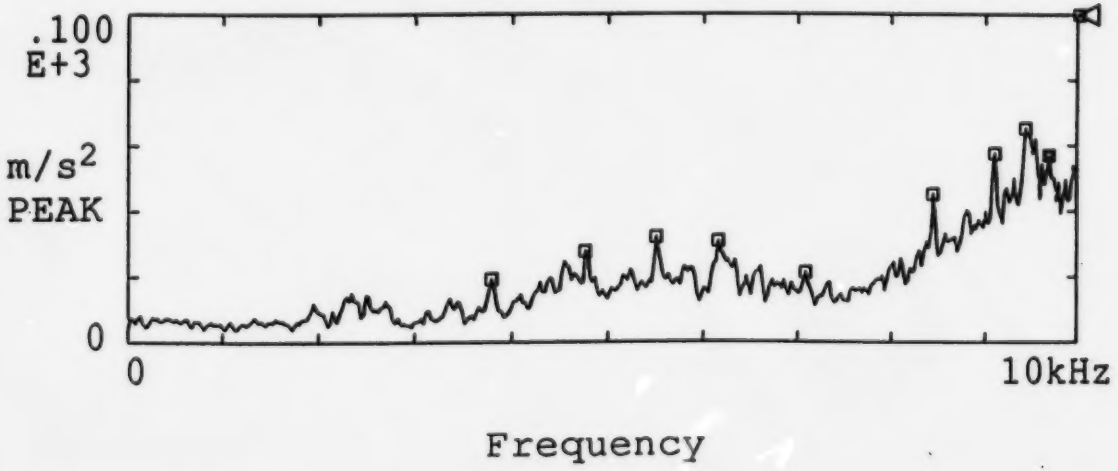

FIGURE 25

DNGS U2 LRV 4 VALVE TEST L-26, LOCATION 3 AXIAL ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	2375Hz	.380E+2	m/s^2
2	4325	.189E+2	
3	4775	.150E+2	
4	5425	.929E+1	
5	6200	.101E+2	
6	6850	.836E+1	
7	7675	.155E+2	
8	8125	.150E+2	
9	9425	.180E+2	
10	overall	.172E+3	

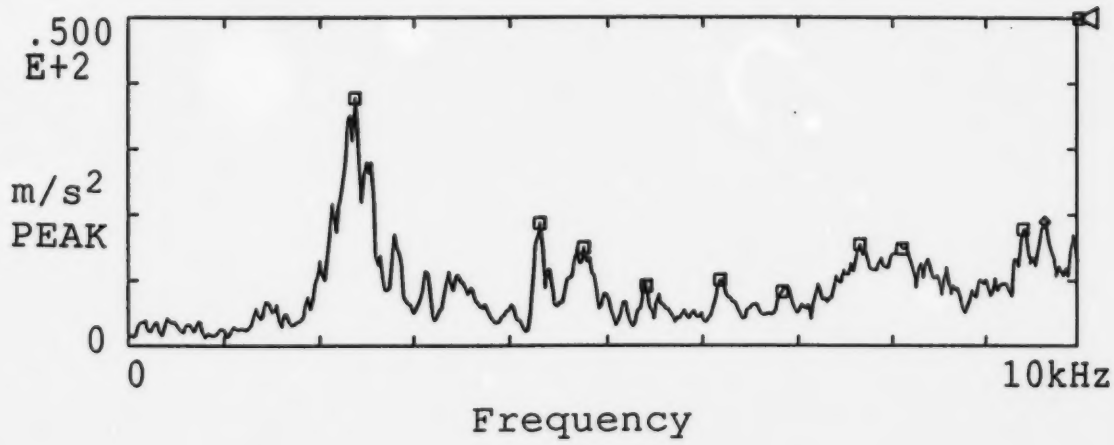

FIGURE 26

DNGS U2 LRV 4 VALVE TEST L-26, LOCATION 3 VERT ACC M/S2 26-AUG-88

PEAK SPECTRUM

1	3125Hz	.387E+2	m/s^2
2	3475	.297E+2	
3	4300	.207E+2	
4	5100	.279E+2	
5	5225	.230E+2	
6	5525	.157E+2	
7	7425	.104E+2	
8	8050	.105E+2	
9	8500	.106E+2	
10	overall	.178E+3	

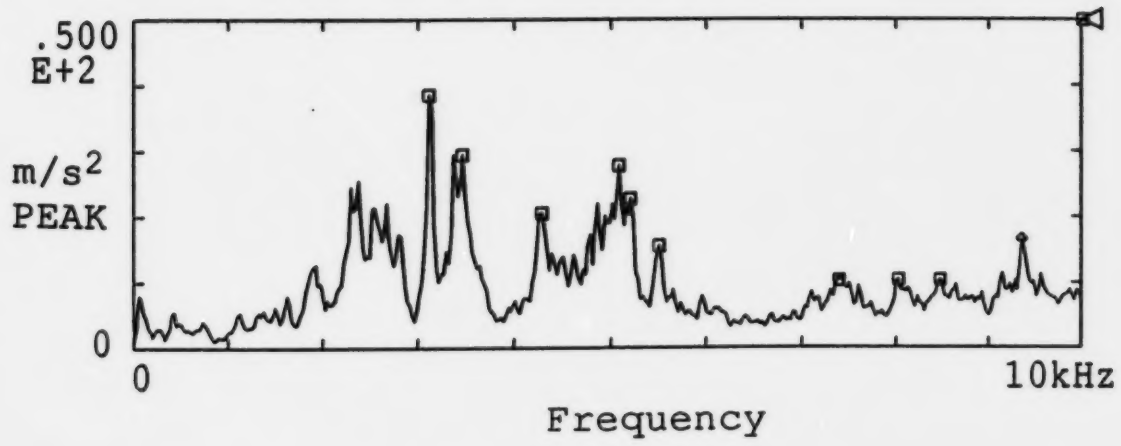

FIGURE 27

DNGS U2 LRV 4 VALVE TEST L-25, LOCATION 4 VERT ACC M/S2 26-AUG-88

	PEAK SPECTRUM		
1	3150Hz	.134E+2	m/s^2
2	4275	.141E+2	
3	4775	.247E+2	
4	5225	.112E+2	
5	6175	.257E+2	
6	6650	.127E+2	
7	7300	.176E+2	
8	7800	.134E+2	
9	8675	.147E+2	
10	overall	.138E+3